FEEDING AND PREY PREPARATION IN THE SOLPUGID, *EREMORHAX MAGNUS* HANCOCK (SOLPUGIDA: EREMOBATIDAE)

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Abstract.—Prey preparation as an important component of handling time is demonstrated for the first time in a solpugid (*Eremorhax magnus* Hancock). Prey body parts (from the grasshopper, *Trimerotropis pallidipennis* Walker) characterized by high chitin content (head, antennae, wings, legs) are selectively removed prior to ingestion. Head capsules were removed in 77–84% of the feeding trials, depending on the size of the prey, followed by forewings (54%) and hindwings (37%). Body parts possessing lower amounts of chitin (abdomen, thorax, hind femur) are processed and ingested thereby supporting the nutrient concentration hypothesis. Prey is initially detected via the palpi which are then used to pull the prey toward the chelicerae. The prey is then grasped by the chelicerae which are then used to fragment and grind the prey for ingestion. Ingestion time ranged from 6.2–17.4 min for small hoppers, and 11.6–28.3 min for larger prey.

Key Words.—Arachnida, Solpugida, *Eremorhax*, prey preparation, feeding

Previous studies have shown that predators frequently consume only certain parts of their prey (Haynes & Sisojevic 1966, Sih 1980) and often show strong preferences for specific tissues and body regions (Curio 1976; Punzo 1989, 1992). For example, insectivorous birds frequently remove the wings, legs and head capsule, and swallow the thorax and abdomen (Sherry & McDade 1982). Some lycosid and thomisid spiders preferentially ingest the softer tissues of an insect's abdomen while rejecting other body regions depending on the degree of hunger (Haynes & Sisojevic 1966, Nentwig 1987, Punzo 1991). In many cases insectivorous birds and mammals will modify or remove specific prey parts before ingestion is initiated (Curio 1976). This has also been reported for a few arthropod predators such as mantids and some decapod crustaceans (Krebs & McCleery 1984). Although this type of behavior, known as prey preparation, increases the overall handling time, it can help to optimize energy budgets by targeting the ingestion of those body parts possessing a higher concentration of essential nutrients (Hespeheide 1973, Kaspari 1990). One way for insectivores to maximize nutrient intake rate would be to reject those prey parts having a high chitin content. Chitin is either indigestible or poorly digested by insectivores in general (Punzo 1989, Scott et al. 1976).

Research on optimal foraging has focused on energy expenditure associated with search, pursuit, capture, ingestion and resource depression (Charnov 1976, Lucas 1983, Punzo 1989, Punzo & Garman 1989) whereas prey preparation has received little attention (Kaspari 1990). The few available studies focus on vertebrate predators (see reviews by Curio 1976, Krebs & McCleery 1984, O'Brien et al. 1990). In this paper, I explore the relationship between chitin content and prey preparation in the solpugid, *Eremorhax magnus* (Hancock). This is the first demonstration that solpugids make decisions concerning which prey parts should be selectively consumed.

MATERIALS AND METHODS

Eremorhax magnus is a common inhabitant of the desert regions of southern California (Muma 1951). Adult females (29–35 mm, total body length) were collected as they wandered the surface at night during June–August, 1992. Solpugids were collected within a 10-km radius of Victorville (San Bernardino County), CA. A helmet-mounted light with a red filter was used to locate and observe solpugids as described by Punzo (in press). A total of 56 females were collected and transported back to the laboratory. Solpugids were housed individually in plastic cages (30 × 14 × 8 cm), provided with water, and fed once per week on a diet of mealworm larvae (*Tenebrio molitor* L.).

Twenty solpugids were randomly assigned to one of two experimental groups. Each experimental group was allowed to feed on one of two prey size classes: (1) small (juveniles): total body length (TBL): 12–16 mm; body weight (BW): 0.31 ± 0.02 g; (2) large: TBL: 17–22 mm; BW: 0.84 ± 0.03 g. I chose pallid-winged grasshopper females (*Trimerotropis pallidipennis* Walker) as the prey species for all feeding experiments. This grasshopper is common in this area (personal observation) and three of the solpugids had a pallid-winged grasshopper in their chelicerae when they were collected. Specimens of *T. pallidipennis* were collected with a sweep net and also brought back to the laboratory for subsequent use in feeding trials. All solpugids were deprived of food for 72 h prior to testing.

Grasshoppers from each prey size class were used to assess the chitin content (mean weight and percent chitin) of various body parts: head, antennae, abdomen, hind femur, foreleg, midleg, thorax, forewing and hindwing. Chitin weight was determined according to the method described by Zach & Falls (1978). Body parts were freeze-dried, weighed on a Metler electronic analytical balance, immersed in 2.0 M KOH for 72 h, rinsed, dried again and reweighed. KOH dissolves all tissues except chitin.

For feeding trials, each solpugid was presented with a grasshopper from one of the designated size classes. Feeding trials were recorded with a Cine-8 High Speed Camera (Visual Instrumentation Corp.) at 100 frames/sec. A Lafayette Super 8 Analyzer (Model 1026) was used for frame-by-frame analysis as described by Punzo (1989). I recorded the removal time (sec), defined as the amount of time that elapsed from the moment the prey was grasped until a particular body part was detached.

I used the data recorded for chitin content to determine whether or not there was any evidence of nutrient concentration. According to the nutrient concentration hypothesis (Foster 1987, Kaspari 1990), the removal of prey parts possessing high amounts of indigestible chitin (prey preparation) should result in the concentration of utilizable nutrients while maximizing the amount of space in the gut available for additional food items. I calculated the difference in nutrient concentration when a particular body part was removed from the grasshopper using the data collected on chitin content. The various body parts were subsequently ranked by dividing the mean removal time for each body part by its chitin content as described by Kaspari (1991).

Statistical analyses followed procedures described by Sokal & Rohlf (1981). Prey-part rankings were obtained by Tukey's multiple comparison test; this yielded statistical clusters of body parts. These clusters related to predicted perfor-

Table 1.   Mean chitin weight (mg) and percent chitin (%) of several body parts for two size classes of the grasshopper, *Trimerotropis pallidipennis.*

Body part	Grasshopper size class							
	Small				Large			
	n	Mean weight	SD	%	n	Mean weight	SD	%
Head	10	2.34	0.32	37.7	9	5.85	0.84	40.4
Antennae	10	0.13	0.02	41.2	10	0.32	0.03	43.6
Abdomen	9	2.77	0.41	9.7	8	6.47	0.72	12.3
Thorax	10	0.51	0.14	21.1	10	1.24	0.31	25.2
Hind femur	10	1.91	0.17	17.4	9	2.87	0.26	18.3
Foreleg	10	0.31	0.04	43.4	10	0.54	0.07	41.2
Midleg	8	0.20	0.02	35.4	10	0.42	0.03	39.7
Front wing					8	1.10	0.16	48.7
Hindwing					10	1.57	0.38	61.4

mances of the solpugids at each combination of predator and prey size. Kendall's measure of concordance was used to assess between-predator and between-prey size similarity in consumption frequencies. For all solpugids, I determined the mean consumption frequency for each prey body part in order to estimate any possible preferences as described by Lucas (1983) and Kaspari (1990). Tukey's multiple comparison test clustered prey parts according to similar consumption frequencies. All tests were two-tailed with significance levels set at $P = 0.05$.

RESULTS AND DISCUSSION

Values for mean chitin weights and percentages for various body parts of *T. pallidipennis* are listed in Table 1. Head capsules, antennae, forelegs, midlegs and both pairs of wings are all characterized by relatively high chitin content (35.4–61.4%) as compared to the abdomen (9.7–12.3%), thorax (21.1–25.2%) and hind femur (17.4–18.3%). Analyses of feeding trials indicate that *E. magnus* selectively removes the head capsule and wings (Table 2) and focuses its feeding on those body parts containing the least amount of indigestible chitin such as the abdomen, thorax and hind femur.

Table 2.   Removal time (sec) of *Eremorhax magnus* for grasshopper body parts from two different size classes.

Body part	Grasshopper size class			
	Small		Large	
	n	Mean (SD)	n	Mean (SD)
Head and antennae[a]	20	37.3 (7.4)	23	72.4 (9.1)
Abdomen	17	NR[b]	15	NR
Thorax	19	NR	20	NR
Hind femur	18	NR	14	NR
Forewing			12	14.8 (3.6)
Hindwing			14	17.1 (6.1)

[a] Significant between-grasshopper size differences ($P < 0.01$).
[b] NR = body part not removed (grinded vigorously between chelicerae).

Solpugids consumed prey parts from each prey size class in similar frequencies (Kendall's W = 0.57, $P < 0.05$ for small prey; W = 0.84, $P < 0.01$ for large prey) except for fore- and hindwings which were very small in the smaller hoppers and usually ingested with the rest of the thorax. The Tukey tests indicated the following clusters of consumption frequencies: for the larger prey size category, the head capsules were removed in 84% of the feeding trials whereas forewings and hindwings were removed in lower frequencies (54 and 37%, respectively). For the small grasshoppers, head capsules were removed in 77% of the feeding trials. Kendall's concordance was significant (W = 0.852, $P < 0.01$) for the mean consumption frequencies of body parts for each prey size class indicating that the same criteria were involved in decisions to remove prey parts from both small and large prey.

Video recordings also showed a rather stereotyped feeding behavior pattern for these solpugids feeding on grasshoppers. In all cases, *E. magnus* females responded quickly to tactile stimuli upon contact of prey with their palpi or legs. Following initial contact, the grasshopper is pulled toward the chelicerae by the palpi. The prey is then grasped firmly with the chelicerae. This is followed by a vertical motion of the movable cheliceral finger against the upper fondal teeth resulting in the fragmentation and grinding of prey tissues. During the movement of the prey through the cheliceral mill, certain body parts are severed and removed, and others are retained for further processing and subsequent ingestion (Table 2). Although the forelegs, midlegs and hind tibiae were discarded, the hind femur was processed through the chelicerae allowing these solpugids to ingest the mass of muscle tissue associated with these saltatorial legs. This was not observed when *E. magnus* fed on other types of arthropods such as beetles and spiders. Previous observations on feeding behavior in other species have indicated that in some cases the prey is actually stabbed with the chelicerae upon initial contact (Bolwig 1952, Cloudsley-Thompson 1977, Turner 1916). This was not observed in *E. magnus* for any feeding trial. Some investigators have reported stalking of prey by some solpugids such as *Hemerotrecha californica* Chamberlin and *Galeodes* sp. (Muma 1966) but this behavior was not observed for *E. magnus*. The amount of time required by *E. magnus* to ingest small grasshoppers ranged from 6.2–17.4 min; for larger grasshoppers ingestion time ranged from 11.6–28.3 min.

The results from this study are the first demonstration that prey preparation is an important component of handling time for a solpugid. By removing body parts difficult to digest, *E. magnus* is maximizing the concentration of nutrients that can be digested and absorbed as well as the amount of space available in the gut to receive additional food. These benefits may outweigh the cost associated with an increase in the overall handling time that accompanies prey preparation.

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